Financial analysis of seaweed cultivation in Karimunjawa Islands, Indonesia

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Abstract. Karimunjawa Islands is one of the conservation areas in Indonesia which has high biodiversity. Conservation support is needed from all stakeholders, including the local community. Without adequate sources of income, the local community has the potential to behave destructively, including logging mangrove trees and damaging coral reefs. One of the environmentally friendly jobs in Karimunjawa Islands is seaweed cultivation, especially in Kemojan Village. The purpose of this research was to make a financial analysis of seaweed (*Eucheuma cottonii*) farming in Kemojan Village. We conducted a survey of 90 seaweed farmers in Kemojan Village. We calculated profit, RC ratio, CR ratio and BEP (price). This research proved that the seaweed cultivation business in Kemojan Village can be an adequate source of income for the local people of Kemojan Village. The average profit is IDR. 63,749,572 per year, with an RC ratio of 6.04 or CR ratio of 0.17. BEP (price) of seaweed is IDR 248 per kg wet, while the price at the time of the study is IDR 1,500 per kg wet. By increasing the welfare of Kemojan Village people through seaweed cultivation, it is hoped that the local community will increasingly support conservation in Karimunjawa Islands.
Key Words: BEP, CR ratio, *Eucheuma cottonii*, Karimunjawa islands, RC ratio.

Introduction. Karimunjawa Islands is one of the conservation areas in Indonesia. Karimunjawa Islands have five intrinsic ecosystems, including lowland tropical forests, mangrove forests, coastal forests, seagrasses and coral reefs. The location of Karimunjawa Islands is 5°40'39" to 5°55'00" latitude and 110°05'57" to 110°31'15" east longitude. Biodiversity of Karimunjawa region is very diverse. There are 45 types of mangrove trees, 205 types of anthozoa (182 type of scleractinian and 23 types of non-scleractinian), 32 types of macro algae, 9 types of seagrass, 412 species of fish, as well as various types of mammals, reptiles, butterflies, insecta, plathyhelmintes, annelids, gastropods, bivalves, cephalopods, arthropods, echinoderms, porifers and macrobenthos (BTN Karimunjawa 2017; Hafsaridewi et al 2018). Because of the high biodiversity in Karimunjawa Islands, it is necessary to get support from all stakeholders, including the local people of Karimunjawa Islands.

Local communities will support conservation if they understand the benefit of conservation. Community welfare is also important to support conservation. Without adequate source of livelihood to supply their daily needs, the local community will tend to behave destructively, including damaging coral reefs and logging mangrove trees (Zamroni 2018). According to Hafsaridewi et al (2018), the problems in Karimunjawa Islands are largely anthropogenic. That is logging mangrove, land use change, and destructive fishing practices. Poverty is generally as the major problem faced by Indonesian coastal communities as the largest archipelago country in the world. The majority of the population that inhabits the islands earns income from the sea and agriculture. Fisheries and agriculture are two sectors that have relatively high poverty population. According to Putro et al (2016), poverty on Karimunjawa slands is categorized as income poverty, this is caused by the inability of local people to manage and maximize the potential of local resources. BPS-Statistics of Jepara Regency (2018) stated that around 24.56% of 2817 households in Karimujawa Islands have a pre-welfare

category in 2017. This condition proved that the local community of Karimunjawa Islands cannot optimize the resources of Karimunjawa Islands yet.

The growing business in Karimunjawa Islands is tourism. In 2018, the number of foreign tourists coming to Karimunjawa were 8,156 people, while domestic tourists were 129,679 people. Tourism business services are more developed in Karimunjawa Island (Karimunjawa Village), while in Kemojan Island (Kemojan Village) and others are still underdeveloped yet. As an illustration, there are 11 hotels and 73 non-hotel lodging businesses in Karimunjawa Island, while there are only 4 hotels and 4 non-hotel lodgings in Kemojan Island. In Parang Island (Parang Village), there is only 1 non-hotel lodging (BPS-Statistic of Jepara Regency 2019). It shows that the tourism business has not developed evenly in Karimunjawa islands. Therefore, business diversification needs to be developed to improve the welfare of the local people of Karimunjawa Islands. In addition, tourism cannot be fully relied on because tourism in Karimunjawa Islands is conservation-based tourism, not mass tourism.

One of the jobs that does not conflict with the principle of conservation in Karimunjawa Islands is seaweed farming. Seaweeds are macroalgae (multi-cellular plants). Macroalgae is continuously washed in water and takes nutrients directly from the water. Seaweeds need carbon, dissolved nutrients (including nitrogen and phosphate), trace elements, and other compounds from the seawater plus sunlight to grow. Seaweed growth is controlled by the availability of sunlight and nutrients (Roesijadi et al 2008). Seaweed farming has developed in many coastal and small islands in Indonesia, including in Karimunjawa Islands. *Eucheuma* spp. is one of the main seaweed commodities cultivated by seaweed farmers in the world. The main use of *Eucheuma* spp. is for carrageenans. Indonesia is known as one of the major producers of *E. cottonii* in the world (Mulyati 2015; FAO 2016; Buschmann et al 2017). *Eucheuma* sp. is included in division of Rhodophyta (red algae). The use of red algae in the world includes the carrageenan (including *E. cottonii*) and agar (especially *Gracilaria* sp.). In addition, there is also a division of Phaeophyta (brown algae) which is used for alginates, including *Sargassum* sp. and *Tubinaria* sp. While divisions of Chlorophyta (green algae) and Cyanophycota (blue-green algae) are used as vegetables and salads, including *Caulerpa* sp., *Symploca* sp. and *Lyngbia* sp. (Mulyati 2015).

Seaweed cultivation in Karimunjawa Islands is centered on the coast of Kemojan Village or Kemojan Island. The purpose of this research was to make a financial analysis of seaweed (especially *E. cottonii*) farming in Kemojan Village. The profit of seaweed farming can be one of welfare indicators of Kemojan Village people. The results of this study can be a reference in the management of seaweed farming in Karimunjawa Islands.

Material and Method

Research time. This research was conducted in June to August 2019.

Research object. The object of this research was seaweed farming of *E. cottonii* in Kemojan Village. According to Mulyati (2015), Java region (including Karimunjawa Islands) was only accounted for 9.4% of *Eucheuma* commodity production of Indonesia, with the largest producer was Sulawesi region that reach 56.3%. Seaweed cultivation in Kemojan Village is carried out using the longline method with relatively simple technology.

Research location. This research location was in Kemojan Village (can be seen in Figure 1). The people of Kemojan Village plant seaweed in the northwestern coast waters of Kemojan Village. Kemojan Village is located on Kemojan Island. Kemojan Island and Karimunjawa Island are the largest islands in Karimunjawa Islands. Karimunjawa Island and Kemojan Island are very close and have been connected with bridge. The location of seaweed cultivation on the coast of Kemojan Island is in accordance with the water zone in Karimunjawa conservation area.

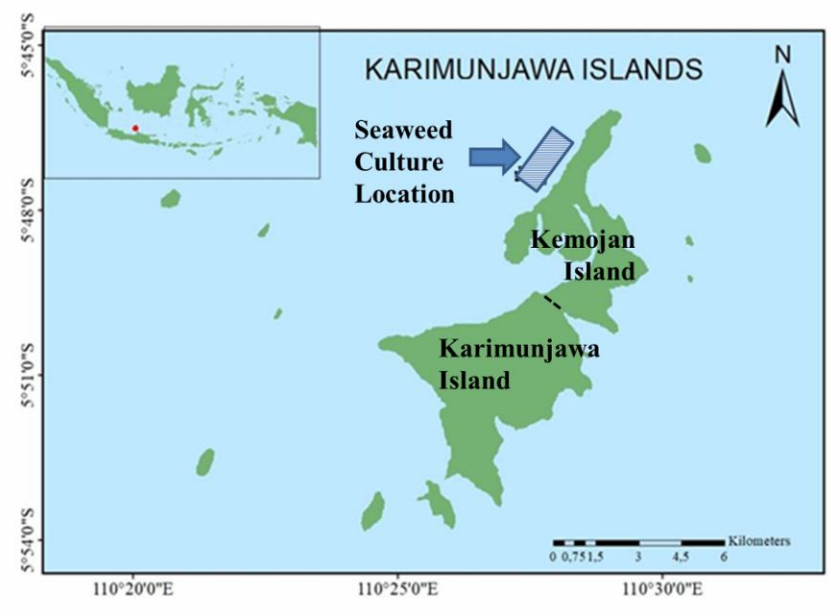


Figure 1. The research location.

Respondents. The respondent of this research were 90 seaweed farmers from Kemojan Village. The seaweed farmers in Kemojan Village are spread across four sub-village in Kemojan Village. Researchers went to the location of seaweed cultivation and interviewed every farmer who was willing to be a respondent.

Indepth interview and observation. The main data in this research was obtained through in-depth interviews. Respondents were asked to answer a list of questions to explore data and information related to seaweed farming. Researchers also conducted field observations and secondary data collection, namely statistical data published by BPS-Statistics of Jepara Regency as a government agency authorized to issue statistical data.

Financial analysis. Financial analysis in this research was conducted using profit analysis, CR (cost revenue) ratio, RC (revenue cost) ratio, and BEP (break even point). Several researchers who used RC ratio and CR ratio include: Pio et al (2016), Hapsari & Fitri (2016), Najamuddin et al (2017), Budiasa et al (2018), Bambang et al (2019) and Wijayanto et al (2019). RC ratio is the opposite of CR ratio.

$$\text{CR ratio} = TC / TR \quad (1)$$

$$\text{RC ratio} = TR / TC \quad (2)$$

$$\pi = TR - TC \quad (3)$$

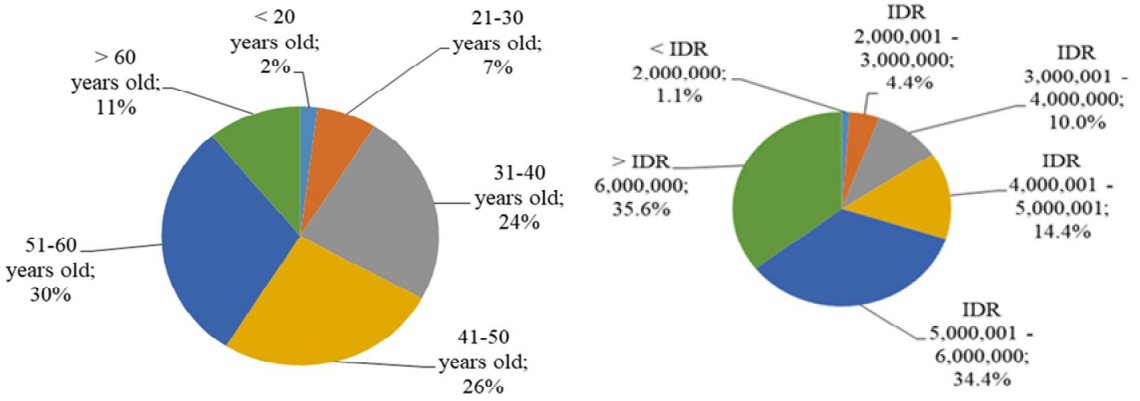
$$\text{BEP} = TC / Q \quad (4)$$

TR is total revenue (IDR). TC is total cost (IDR). π is profit (IDR). Q is quantity of production (kg, wet weight basis). The business of seaweed culture is considered profitable if CR ratio is less than 1.0. By using RC ratio, if the value greater than 1.0 is considered profitable because of total revenue is greater than total cost.

Results and Discussion. Karimunjawa Islands consists of 27 islands and has a land area of 71,200 km^2. Administratively, Karimunjawa Islands is a sub-regency of Jepara Regency. Karimunjawa Sub-regency consists of 4 villages, namely Karimunjawa, Kemojan, Parang, and Nyamuk (BPS-Statistic of Jepara Regency 2019).

Characteristics of respondents. Seaweed farmers who were respondents in our research have a diverse age, from 20 to 80 years with an average age of 47 years. Most respondents has productive age (can be seen in Figure 2), only 11% are over 60 years old. However, there are respondents aged 62 years and 64 years who still cultivated seaweed as many as 50 longline units with a length per unit of around 150 m or total

length of 7500 m, while the average total length of longline was 2360 m. That is, even though they were above 60 years old, but their physical condition is still relatively strong. According to Nyundo (2017), seaweed farmers in Kenya were also found aged 60-80 years. This shows that some coastal people over 60 years old are still ready to work hard.



a. By age b. By house-hold expences per month

Figure 2. Composition of respondents.

The average monthly house-hold expenditure of respondent is IDR. 3,989,611, with the lowest of IDR 1,700,000 and the highest of IDR 6,600,000. The cost of living in Karimunjawa Islands is relatively higher than Java island (as closest large island) because most of the living needs of Karimunjawa Islands people still have to be supplied from Java island.

There were 2,945 house-holds living in Karimunjawa Islands in 2018. The Karimunjawa population was 9,514 person with a population growth of 1.42% per year. The proportion of the male and female are relatively balanced, that was 4,795 men and 4,719 women. The population density of Karimunjawa was 136 person per km^2 (BPS-Statistic of Jepara Regency 2019).

The area of Kemojan Village is 16.26 km^2, while the area of Karimunjawa Village is 46.24 km^2. Administratively, Kemojan Village is divided into 4 sub-village. The number of house-holds in Kemojan Village was 764 house-holds. In 2017, the male population was 1,501 person, and women was 1,484 person. Population density of Kemojan Village was 184 person per km^2 (BPS-Statistic of Jepara Regency 2018).

The people of Kemojan Village are multi-ethnic. According to Nirmala (2017), Kemojan Island community uses several languages, including Javanese, Buginese, Maduranese, Mandarese, and Indonesian languange. According to Suliyati et al (2017), the main ethnics in Karimunjawa islands are Javanese, Buginese and Madurese. People in Karimunjawa Islands are all immigrants from various regions in Indonesia, such as Javanese, Buginese, Makassarese, Madurese, Bajo, Banjar, and Buton who have a maritime ethnic background with their livelihood on the sea.

In general, the level education of Karimunjawa Islands community is relatively low. Only 1.8% of the population graduated from higher education, 6.2% graduated from senior high school, 10.5% graduated from junior high school, and the rest only graduated from elementary school, did not complete elementary school and some even never had formal education at all. This affects people's competence in working and optimizing the potential of local economy. Most of Karimunjawa people work as farmers and fishermen (72.4%). The agriculture developed by the local community included rice, mango, banana, clove, coconut, kapok, breadfruit and guava. Although there are rice fields in Karimunjawa Islands, but their production is still unable to meet the local demand, so that some rice is still imported from Java. Karimunjawa community also bring a number of goods from Java, including sugar, salt, vegetables, fruit, house-hold appliances, and building materials using sea transportation services. While livestock raised by

Karimunjawa people includes beef cattle, goats, chickens, and ducks. Karimunjawa fishermen use 200 ships and 306 outboard motorboats (BPS-Statistic of Jepara Regency 2019). While the status of pre-prosperous house-holds in Kemojan Village is 27.8% (BPS-Statistic of Jepara Regency 2018). This condition shows that the welfare of Kemojan people still needs to be improved.

Several seaweed farmers in Kemojan Village are women. The same condition is also found in other regions of the world. Even in Zanzibar, 90% of seaweed farmers were women (San 2012; Neish & Msuya 2013; Nyundo 2017). Thus, seaweed farming can become a business diversification to improve the welfare of coastal people. According to Bjerregaard et al (2015), the expansion of seaweed farming in tropical developing countries has significant positive impacts to reduce local poverty, climate change mitigation and improve ecosystem management.

Seaweed culture operation. Seaweed cultivation conducted by the Kemojan people uses *E. cottonii*. According to San (2012), *Eucheuma* sp. seeds from the Philippines and Indonesia have the best quality with relatively high growth. The sea-waters of Karimunjawa Islands are still in relatively good condition, as evidenced by high biodiversity. According to Sugianti & Mujiyanto (2014), their research using the saprobitas method showed that some waters in Karimunjawa were low polluted, including the location of seaweed cultivation in Kemojan island. According to Nyundo (2017), ecological and socio-cultural conditions are the most success factors in seaweed farming.

The seaweed cultivation process starts from preparation. Preparation include the procurement of equipment, both boat, longlines and seeds. Seaweed farmers in Kemojan Island use a boat without motor (can be seen in Figure 3) with a length of 3 m. In this research, the cost of boat purchasing was in the range of IDR 1,500,000 to IDR 2,500,000 depending on wood material and quality of workmanship. The cultivation method uses longline. The buoy uses a drink bottle used and jerrycan. Ballast uses stone. The rope uses Polyethilene or PE (size of 8 mm and 6 mm). While the length of the rope used varies between seaweed farmers. To tie seaweed seeds, raffia is used. So, investment in seaweed farming is relatively small.

Figure 3. Seaweed culture in Kemojan Village.

Although seaweed can be found in the waters of Karimunjawa, but seaweed seeds are supplied from outside the region. This is due to the high need for seaweed seeds. Seaweed seed supplies is obtained from the Center of Marine Culture (government-owned) in Lampung and Sulawesi. In the next cultivation period, farmers use a portion of the seaweed harvest to be used as seeds (vegetative). The selected seed is seaweed with thallus has many branches, pointed edges and has no disease. Seaweed with small thalus has faster growth than larger thalus.

The number of longline used by seaweed farmers in Kemojan Village varies. At least they use 3 units of longline, while the most use 50 units. The average longline used by seaweed farmers is 19 units. The length of the longline used varies, between 75 to 225 m per longline with an average length of 129 m per longline. If added, the average total length of 2360 m, the longest of 7500 m and the shortest of 360 m. The number and length of longline used by seaweed farmers in Kemojan Village depend on the ability to manage and availability of the water space. The seaweed farmers in Kemojan Village

do not need a permit to cultivate seaweed. So, it is vulnerable about conflicts between farmers related to cultivation sites. If there is a conflict, then it is resolved through deliberation, where the kinship in Kemojan Village is still very strong. The time of seaweed cultivation in Kemojan Village is between 30 and 65 days, with an average of 42 days. While the duration of cultivation of *Kappaphycus alvarezii* or *E. cottonii* in Tamil Nadu (India) are 30-35 days (Radhika & Gayathri 2014). The average productivity of seaweed farming in Kemojan Village is 3.1 kg wet per meter of longline in one cultivation cycle, with a minimum productivity of 1.3 kg wet per meter and the highest 4.5 kg wet per meter.

Most seaweed farmers in Kemojan Village plant seaweed for 10 months per year. In January and February, sea-waves are usually relatively large, so that some seaweed farmers do not plant seaweed. However, there are also seaweed farmers in Kemojan Village who plant throughout the year, including for maintaining seed availability.

Most seaweed farmers have formed seaweed farmer organizations. The organization is useful for information sharing forums, mutual support and is used by the government to facilitate the process of fostering and channeling assistance from the government to seaweed farmers.

Based on the results of interviews, obstacles experienced by seaweed farmers were the availability of seeds, seasons, pests and prices. Related to the sea-wave season, seaweed farmers can modify their cultivation method by using baskets, so that seaweed is still protected in baskets. Regarding the availability of seeds, the local government of Jepara Regency can facilitate the procurement from the Center of Marine Culture, both in Lampung and Sulawesi. In principle, seaweeds can reproduce both asexually (only by dividing vegetative parts to produce new plants) and sexually (Roesijadi et al 2008).

Related to pests, if farmers use baskets, then the problem can be overcome. Pests from seaweed cultivation in Karimunjawa Islands are sea turtles and herbivorous fish. While the parasites found in seaweed cultivation can be overcome by keeping the culture media clean periodically. Related to price, the present price relatively favor for farmers, which is IDR 1,500 per kg wet. In 2018 and earlier, price was around IDR 600 per kg wet. The price increase was proven to increase the interest of Kemojan people to plant seaweed. The government and farmer groups need to increase marketing networks so that there are alternative buyers for competitive price.

In general, seaweed farming in Indonesia is still traditional, with a location in coastal waters. However, intensive scale seaweed cultivation with large capital has been developed in several countries by utilizing offshore waters. According to Roesijadi et al (2008), during World War I (WWI), a chemical industry was established in Southern California to produce acetone and butanol for smokeless gunpowder of the British Navy. After WWI, the facility was closed due to economic reasons. However, at the present it is possible to ferment seaweeds to produce organic chemicals and fuels. At the present, offshore seaweed farms is related to biofuel production from seaweed, and is driven by a search for alternatives to petroleum as a solution to the energy crisis.

Market distribution. At the time of the study, the price of seaweed in Kemojan Village is IDR 1,500 per kg wet and IDR 15,000 per kg dry. If seaweed farmers dry the wet seaweed, then the weight loss reach 90%. Such conditions are relatively similar to those explained by Radhika & Gayathri (2014). Therefore, seaweed farmers in Kemojan Village tend to sell seaweed in wet conditions because selling dry does not provide significant additional benefits.

Based on the survey results, 90 respondents of seaweed farmers in Kemojan Village sell their harvest to 7 seaweed traders from Kemojan Village and 1 seaweed trader from Karimunjawa Village. Seaweed traders from Kemojan Village are a channel of seaweed trader from Karimunjawa Village and companies. So there are 4 businesses in the distribution of seaweed in Kemojan Village, including farmers, small traders, big trader and seaweed processing companies. Figure 4 describes the distribution channels of seaweed in Kemojan Village.

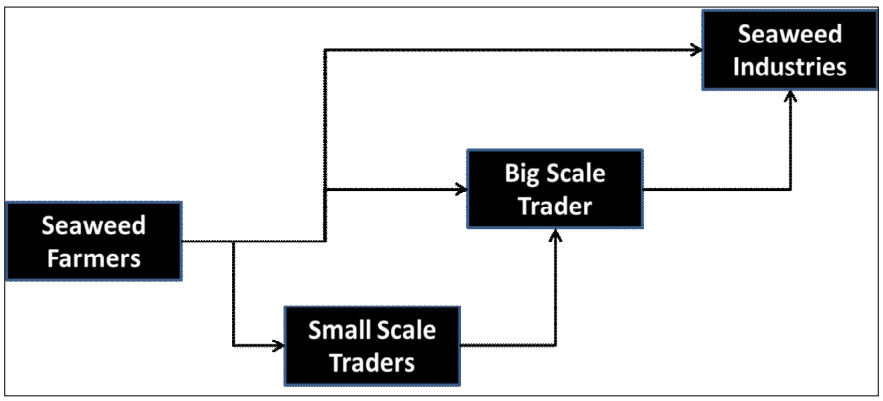


Figure 4. Distribution channels of seaweed in Kemojan Village.

There is a phenomenon of patron-client in the seaweed farming in Kemojan Village. Traders provide loans to seaweed farmers who need fresh money with an agreement that their seaweed yields are sold to lenders. This phenomenon also occurs in other regions of Indonesia, including in Province of Maluku-Indonesia (Ferdinandus et al 2016). In addition, in Kemojan Village, there are also companies that provide seaweed seed facilities as long as the seaweed harvest is sold to the company. This condition makes seaweed farmers vulnerable to uncompetitive prices. Therefore, seaweed farmer organization needs to be optimized to increase bargaining power so that seaweed price is at a reasonable and profitable level.

Financial analysis. Financial analysis was carried out using the average survey results of 90 seaweed farmers. The results of financial analysis can be seen in Table 1. The following assumptions used in financial analysis:

a. the average number of longlines owned by seaweed farmers is 19 units;
b. the frequency of cultivation is 7 cycles per year and there is no seaweed production in 2 months due to weather;
c. average seaweed production per longline per cycle is 391.2 kg wet, so total production per cycle is 7,276 kg wet and total production per year is 50,932 kg wet;
d. the price of seaweed is IDR 1,500 per kg wet;
e. the average investment of a boat without machine is IDR 1,653,409 with an economic age of 3 years;
f. the average longline procurement cost is IDR 19,123,165 for 19 units with an economic age of 2 years;
g. the average cost of purchasing seaweed seeds is IDR 2,411,028 and is only done once a year, while seedlings in the second period and so on use a part of the harvest (vegetative method);
h. planting, maintaining and harvesting seaweed is done by the owner (farmer) himself.

Table 1

Financial analysis

Variables	*Average value*
Revenue	
Revenue per cycle (IDR per cycle)	10,913,903
Total revenue per year (IDR per year)	76,397,318
Cots and assets depreciation	
Boat depreciation (IDR per year)	551,136
Maintenance of boat (IDR per year)	124,000
Longline depreciation (IDR per year)	9,561,582
Purchase the first seeds (IDR per year)	2,411,028
Total cost per year (IDR per year)	12,647,746
Profit	
Profit per year (IDR per year)	63,749,572
Profit per cycle (IDR per cycle)	9,107,082
Profit per longline per cycle (IDR per longline per cycle)	489,628
CR Ratio	0.17
RC Ratio	6.04
BEP-price of seaweed (IDR per kg wet)	248
House-hold expences (IDR per year)	47,875,333
Surplus income of family (IDR per year)	15,874,238

In general, seaweed farming in Karimunjawa Islands is profitable. With a price of IDR 1,500 per kg wet, so seaweed farmers are eager to plant seaweed, because BEP (price) is IDR 248 per kg wet. In 2018 and before, seaweed prices were around IDR 600 per kg wet, and that makes Kemojan people reluctant to plant seaweed because it can unable to fully meet the average house-hold living needs if only using 19 longline units. With a price of IDR 600 per kg of wet, it need 51 longline units to meet the average family living needs for a year.

RC ratio value of 6.04 shows that for every IDR 1 spent by seaweed farmers can produce IDR 6.04. As a comparison, seaweed farming in Karanrang Island (South Sulawesi) produced an RC ratio of 1.94 (Fakhriyyah et al 2015). While the average RC ratio of seaweed cultivation in Kolaka Regency was 1.72 (Asni 2017). The results of study by Ferdinandus et al (2016) proven that an RC ratio of seaweed cultivation in Province of Maluku-Indonesia was 10.36. That is, seaweed cultivation is beneficial in various coastal areas in Indonesia. Therefore, the development of the seaweed industry needs to be done to strengthen the economy of coastal communities.

Although an RC ratio is relatively large, but seaweed farming in Kemojan Village is a small-scale business individually. Seaweed farming in Kemojan Village can generate income that meet the needs of their family. The average respondent has a family living cost of IDR 3,989,611 per month or equivalent to IDR 47,875,333 per year. Seaweed cultivation in Kemojan Village has proven to be a reliable source of income for Kemojan people. By using 14 longline units, Kemojan people can meet the average of family living cost. Some seaweed farmers use a longline of less than 14 units, which means that seaweed farming is not the main source of income for their family. If seaweed farmers increase the number of longlines and plant for a full year using basket, so the income of seaweed farmers can be greater. However, seaweed cultivation in Karimunjawa Islands must still be regulated according to sea-water zoning and adapted to the environment carrying capacity. Without regulation, there will be a conflict of interest with the National Park of Karimunjawa and a social conflict between seaweed farmers.

Conclusions. Seaweed cultivation in Karimunjawa Islands, especially in Kemojan Village, has proven it can be a main source of income for the local community. The average profit of seaweed farming in Kemojan Village is IDR 63,749,572 per year, with an RC ratio of 6.04 or CR ratio of 0.17. This income can meet the average house-hold expenditure and there is a surplus of income to save. This condition has caused the interest of Kemojan

people to plant seaweed has increased significantly. The hope is that improving the welfare of Kemojan people through seaweed farming can support conservation in Karimunjawa Islands. Even so, seaweed cultivation business in Karimunjawa Islands must still be regulated according to the zoning of sea-waters and environment carrying capacity.

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